NICRA

National Innovations on Climate Resilient Agriculture

Agroforestry in mitigation of climate change : Current Status

Prepared by

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BACKGROUND

According to the latest IPCC report, (2014) changes in climate are unequivocal and anthropogenic green house gases are the major drivers of this change. Total anthropogenic GHG emissions have continued to increase over 1970 to 2010 with larger absolute decadal increases towards the end of this period (high confidence). Despite a growing number of climate change mitigation policies, average annual GHG emissions grew by 1.0 Giga tonne carbon dioxide equivalent (Gt CO_2e) (2.2%) per year from 2000 to 2010 as compared to 0.4 Gt CO_2e (1.3%) per year from 1970 to 2000. Total anthropogenic GHG emissions were the highest in human history from 2000 to 2010 and reached 49 (±4.5) Gt CO_2 eq/yr in 2010 (IPCC Working Group III AR5 2014 Summary page 6).

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reduction over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable development. Ecosystem-based options like ecological restoration, soil conservation, afforestation, reforestation and agroforestry, mangrove conservation and replanting, green infrastructure (e.g., shade trees, green roofs), controlling overfishing, fisheries co-management, assisted species migration and dispersal, ecological corridors, seed banks, gene banks and other ex-situ conservation, community-based natural resource management are the future strategies to mitigate climate change in a sustainable manner.

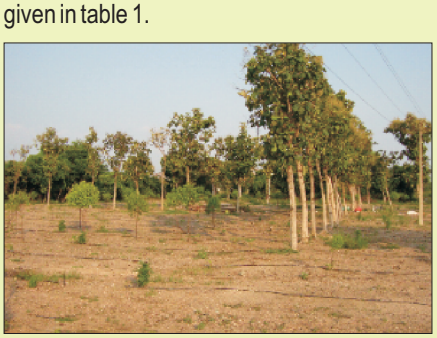
There is a lot of research on climate change, its impact on agriculture, ways and means for stabilizing the atmospheric CO_2 concentration and reducing the CO_2 emissions or increasing the carbon sink. Currently researchers and planners are attempting to increase the carbon storage capacity of terrestrial vegetation through land-use practice such as afforestation, reforestation and agroforestry. Agroforestry system (AFS) has today become an established approach to integrated land management, not only for renewable resource production, but also for climate change mitigation. The carbon storage capacity of agroforestry varies across the species and geography. Further the amount of carbon in any agroforestry system depends upon the structure and function of different components within the system.

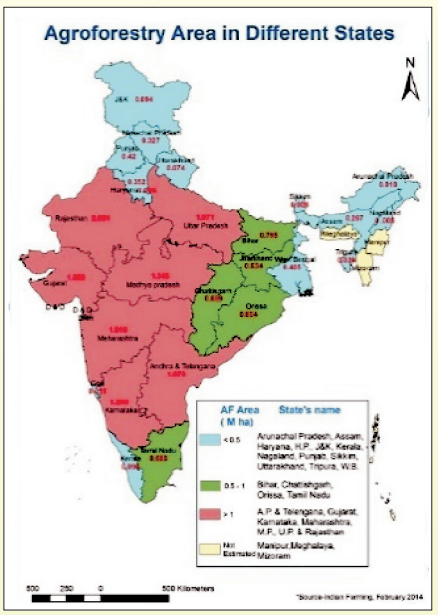
Achievements

ICAR- Central Agroforestry Research Institute, Jhansi has been working since 2011 as one of the partner of NICRA project on three objectives. These include mapping of agroforestry area in the country (using GIS and RS), assess the carbon sequestration potential (CSP) of agroforestry systems existing on farmers fields at national level (using CO2FIX model) and evaluation of thermotolerance of tree species for agroforestry so that right species can be promoted for plantation under increased thermal regime in future. Assessment of CSP has been completed in 51 districts covering 16 states (U.P., Gujarat, Bihar, West Bengal, Rajasthan, Punjab, Haryana, Himachal Pradesh, Maharashtra, Tamil Nadu, Andhra Pradesh, Karnataka, Madhya Pradesh, Chhattisgarh, Orissa and Telangana).

Tree biomass (above and below ground), biomass carbon, soil carbon, net carbon sequestered over simulated period of 30-years and CSP are assessed at district level and same is extrapolated at country level based on 51 districts data across 16 states. Mapping of agroforestry area has been completed for 10 agro-climatic zones out of 15 zones in the country. Initially, area estimation of agroforestry was done based on tree cover (minimum 10% tree cover is set as threshold for agroforestry) and with this appraoch, the area under agroforestry comes out to be 17.45 million ha. This is a preliminary estimate and after completing the mapping in rest of the 5 agro-climatic zone, the final estimate of area under agroforestry will be estimated.

Tree species and their population varied from district to district within the state. However some promising tree species existing in agroforestry systems in different states are given in table 1.





Assessment in 51 districts across 16 states, revealed that the tree population in agroforestry systems existing on farmer's field is about 18.42 trees/ha. Total tree population under agroforestry at national works out to be 321.45 million trees in 17.45 million ha area. On the basis of tree growth (Mean Annual Increment in height and diameter at breast height) tree species existing under agroforestry systems are classified as slow, medium and fast growing trees. The medium growing trees having maximum population (9.0 tree/ha) followed by fast (6.79 tree/ha) and slow growers (2.63 tree/ha) (Figure 1).

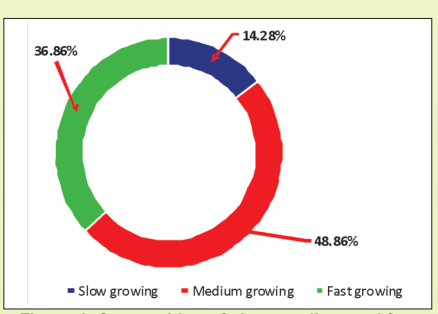


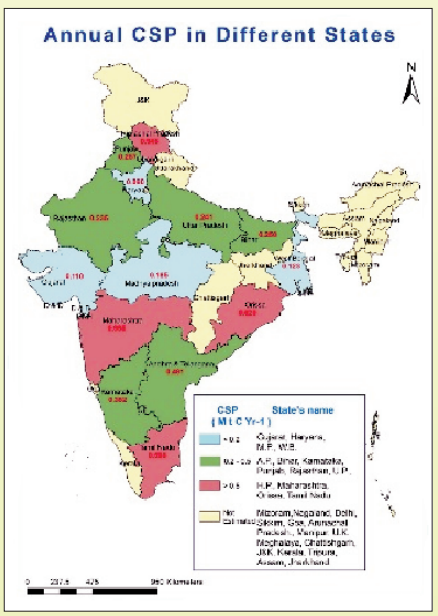
Figure 1. Composition of slow, medium and fast growing tree species in total tree population

Tree biomass under agroforestry is 9.61 tonnes per ha. The average biomass of tress in agroforestry existing on farmer's fields is considered as described earlier (Technical bulletin 2/2017, ICAR-CAFRI, Jhansi). In this way, total biomass of trees (dry mass) under agroforestry systems at national level is 167.69 million tonnes. Similarly, the net carbon sequestered over simulated period of 30-years is 11.35 tonnes C per hectare (Technical Bulletin NICRA 2/2017, ICAR-CAFRI, Jhansi). At national level, the net carbon sequestration would be 198.05 million tonnes with 17.45 million ha of agroforestry area.

Carbon sequestration potential (CSP) of agroforestry systems existing on farmer's

Table 1: Common tree species existing on farmers field in different states.

State	Tree species existing in agroforestry
Punjab	*Eucalyptus tereticornis, Populus deltoides, Melia azedarach, Dalbergia sissoo*
Haryana	*Eucalyptus tereticornis, Populus deltoides, Melia azedarach, Azadirachta indica*
Uttar Pradesh	*Tectona grandis, Eucalyptus tereticornis, Populus deltoides, Azadirachta indica, Acacia nilotica, Madhuca latifolia*
Bihar	*Tectona grandis, Leucaena leucocephala, Albizia procera, Azadirachta indica, Dalbergia sissoo*
West Bengal	*Albizia procera, Terminalia arjuna, Eucalyptus tereticornis, Dalbergia sissoo, Acacia auriculiformis*
Gujarat	*Ailanthus excelsa, Eucalyptus tereticornis, Tectona grandis, Dendrocalamus strictus, Manilkara zapota, Azadirachta indica, Tamarindus indica, Prosopis cineraria*
Rajasthan	*Prosopis cineraria, Tecomella undulata, Acacia tortilis, Ailanthus excelsa, Capparis decidua, Dalbergia sissoo, Azadirachta indica*
Tamil Nadu	*Morus alba, Cocos nucifera, Azadirachta indica, Gliricidia sepium, Leucaena leucocephala*
Karnataka	*Acacia nilotica, Azadirachta indica, Tectona grandis, Areca catechu, Cocos nucifera*
Andhra Pradesh	*Tectona grandis, Cocos nucifera, Acacia nilotica, Azadirachta indica*
Telangana	*Tectona grandis, Pongamia pinnata, Azadirachta indica*
Maharashtra	*Tectona grandis, Pongamia pinnata, Acacia nilotica, Delonix regia, Leucaena leucocephala*
Odisha	*Acacia auriculiformis, Acacia mangium, Cocos nucifera, Musa sapientum, Bambusa vulgaris*
Himachal Pradesh	*Grewia optiva, Leucaena leucocephala, Toona ciliata, Ficus palmata, Morus alba*
Madhya Pradesh	*Madhuca latifolia, Simarouba glauca, Gmelina arborea, Tectona grandis, Azadirachta indica*
Chhattisgarh	*Tectona grandis, Acacia nilotica, Eucalyptus tereticornis, Butea monosperma*



field is 0.35 t C/ha/year. Considering area under agroforestry in the country (17.45 million ha), the total carbon stock will be 6.10 million tones with CO_2 equivalent C will be 22.41 million tonnes. This way, agroforestry can offset 22.41 t CO_2 of total CO_2 equivalent emission (1831.64 million tonnes) in the country (Technical Bulletin NICRA 2/17, ICAR-CAFRI, Jhansi). In other words, contribution of agroforestry to offset total CO_2 eq. GHG emission is 1.22% (Table 2). The forests can offset 69.73 million tonnes CO_2 annually. Similarly, an estimation is made on contribution of different carbon pools in total C stock available in agroforestry at national level (Table 3 and Figure 2). The maximum contribution in total C stock comes from soil organic carbon followed by aboveground biomass, belowground biomass and litter.

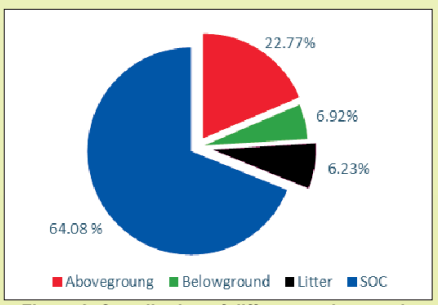


Figure 2. Contribution of different carbon pools in total carbon stock in agroforestry

Table 2. Role of agroforestry to offset CO_2 in total CO_2 Equivalent GHG emission (1831.64 million tonnes*)

Land use (area)	Carbon Sequestration potential t C/ha/year	Total CSP potential million t C	CO2 eq. million tones	Contribution in total GHG emission (%)
A	B	C (A*B)	(C*3.67)	
Agroforestry (17.45 million ha**)	0.35	6.10	22.41	1.22
Forest (69.16 million ha ***)	274725.27	19.0****	69.73	3.80

*Current Science, Vol. 101, NO. 3, 10 August 2011, p409

**Indian Farming 2014, 63(11): 62-64

***Indian Network for Climate Change Assessment (INCCA), Green House Gas Emission, 2007,

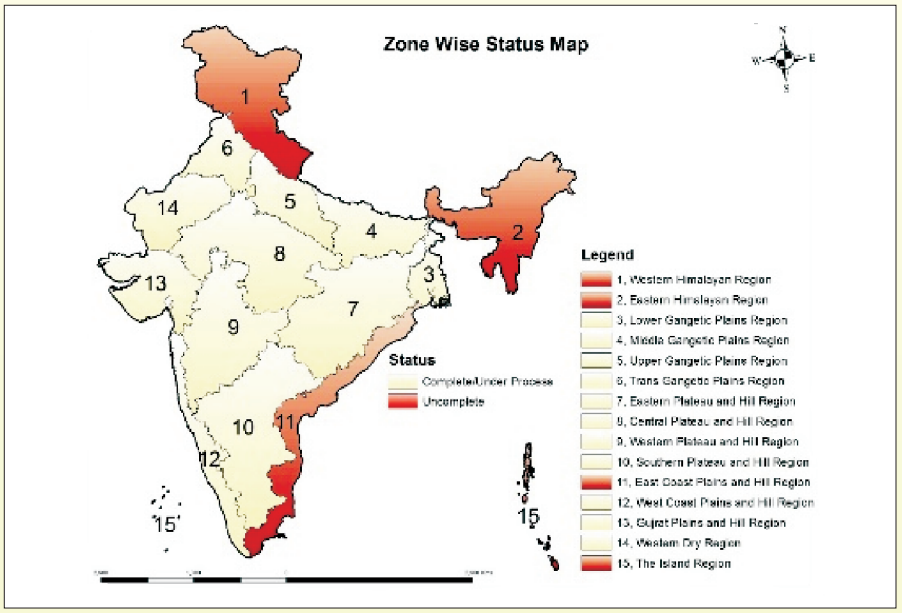
****Ministry of Environment and Forests Government of India, May 2010, p 31

India State of Forests Report (Carbon Stock in India's Forests), 2017,p129

Table 3. Total carbon stock available in different carbon pools under agroforestry (figure in parentheses are carbon in tonnes per ha)

Carbon pool	Total C stock (million tonnes)
Above ground biomass	91.32 (5.23)
Below ground biomass	27.76 (1.59)
Litter	24.97 (1.43)
SOC	257.01 (14.72)
Total	401.06 (22.97)

Land use and land cover (LULC) analysis for selected districts in ten agro-climatic zones (Lower Gangetic Plains, Middle Gangetic Plains, Upper Gangetic plains, Trans-Gangetic plains, Gujarat plains & hill region, Central Plateau & Hill Region, West



Coast Plain and Hill Region, Western Dry region, Western Plateau & Hill Region and southern plateau & Hill Region) was done using RS2/ LISS-3 data. The area under agroforestry in these regions was estimated by sub-pixel classifier, which comes out to be 16.60 million ha of total geographical area (207.90 million ha) covering these regions.

Studies on thermotolerance of multipurpose tree species (MPTs) revealed that in trees studies (*Dalbergia sissoo, Pongamia pinnata, Albizia procera, Azadirachta indica*) elevated temperature (above 2°C than ambient) had a detrimental effect. However *Dalbergia sissoo, Pongamia pinnata* have shown relatively better thermoresilience as compared to other species. Few physio-biochemical traits were identified in these species for thermotolerance.

Future strategies

Realising the importance of adaptation and mitigation the Government of India has launched the National Action Plan on Climate Change (NAPCC in 2008 with eight missions. Greening India Mission (GIM) was one of them, which puts emphasis on increasing tree cover to contribute to adaptation and mitigation, ecosystem services, hydrological services, biodiversity etc.

For mitigating climate change, it is necessary to increase the area under tree cover either in form of bund plantation or in form of tree intercropping with crops. First of all, we have to set the target about area under tree cover like forest, which requires to offset CO_2 from the atmosphere as per greenhouse gas emissions in the country. In the India State Forest Report (ISFR) 2017, tree cover in the country is 93815 sq. kilometre (about 2.85% of total geographical area), which seems to be very less to offset present GHG emission.

Since agroforestry is region specific, the promising tree species of a particular region should be encouraged and farmer's access to quality planting material (QPM) needs to be improved. The other strategies suggested are:

- Identification and promotion of tree species which have good carbon storage capacity.
- Evolve a mechanism for providing incentive to the farmers for ecosystem services.
- Development of agroforestry product value chain by strengthening market infrastructure across the country.

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